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(56) Documents cited

GB 1518238 A

GB 1515428 A

GB 1174038 A

EP 0476975 A1

EP 0461657 A2

EP 0318116 A1

EP 0107217 A1

US 4115719 A

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(54) Flat Image-display apparatus

(57) A flat display apparatus comprises a substrate 41, a plurality of electron sources 42 to 45 on the substrate 41, an electrode 47 facing the electron sources 42 to 45 via a vacuum space 46, and a light emitting means 65 on the side of the electrode 47 which is opposite to the substrate 41, the electrons being successively amplified by each electron source 42 to 45 and being incident upon the light emitting member 65. Primary cathode 53, of molybdenum or tungsten, is saw-tooth shaped at tip 53a and attracting electrodes 55a, 55b direct electrons from second source 43 comprising secondary emitter cathode 57, eg. of caesium oxide or magnesium oxide. Third electron source 44 provides further secondary emission amplification of the electrons from second source 43, and similarly the fourth electron 45 amplifies the electrons from source 44. The voltage difference between successive electron sources 42-45 may be 50-100 volts and a gate electrode 64 may be disposed between the sources and the anode 47.

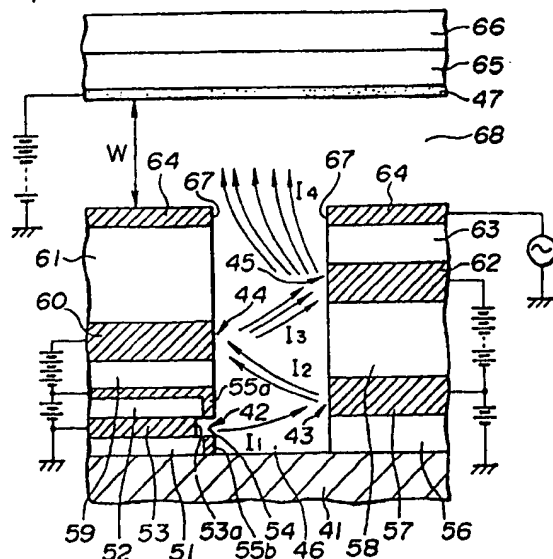
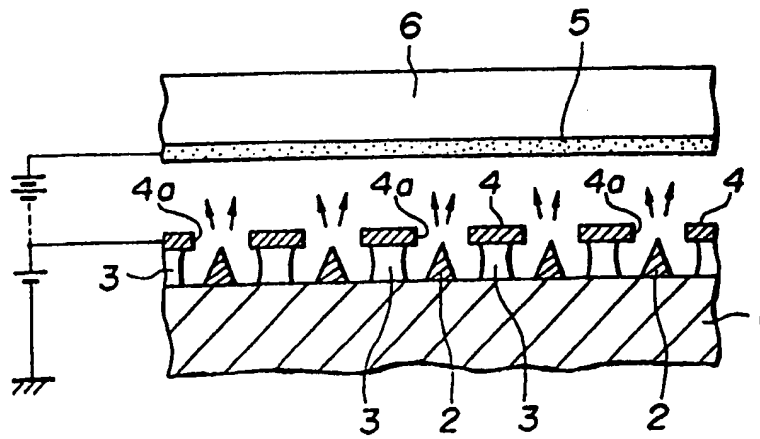
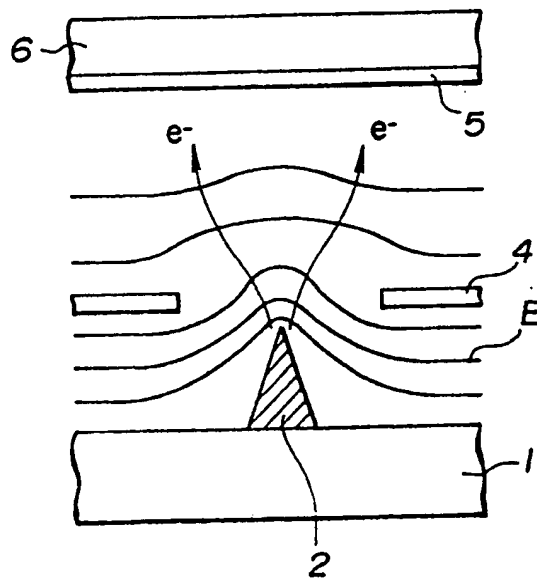


FIG. 6

The date of filing shown above is that provisionally accorded to the application in accordance with the provisions of Section 15(4) of the Patents Act 1977 and is subject to ratification or amendment.

GB 2 259 183 A

**FIG. 1****FIG. 2**

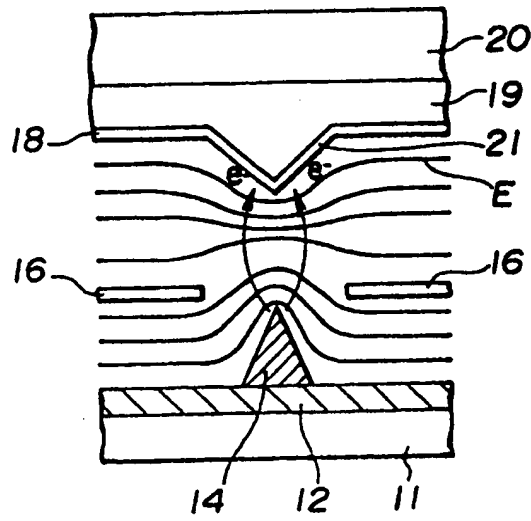
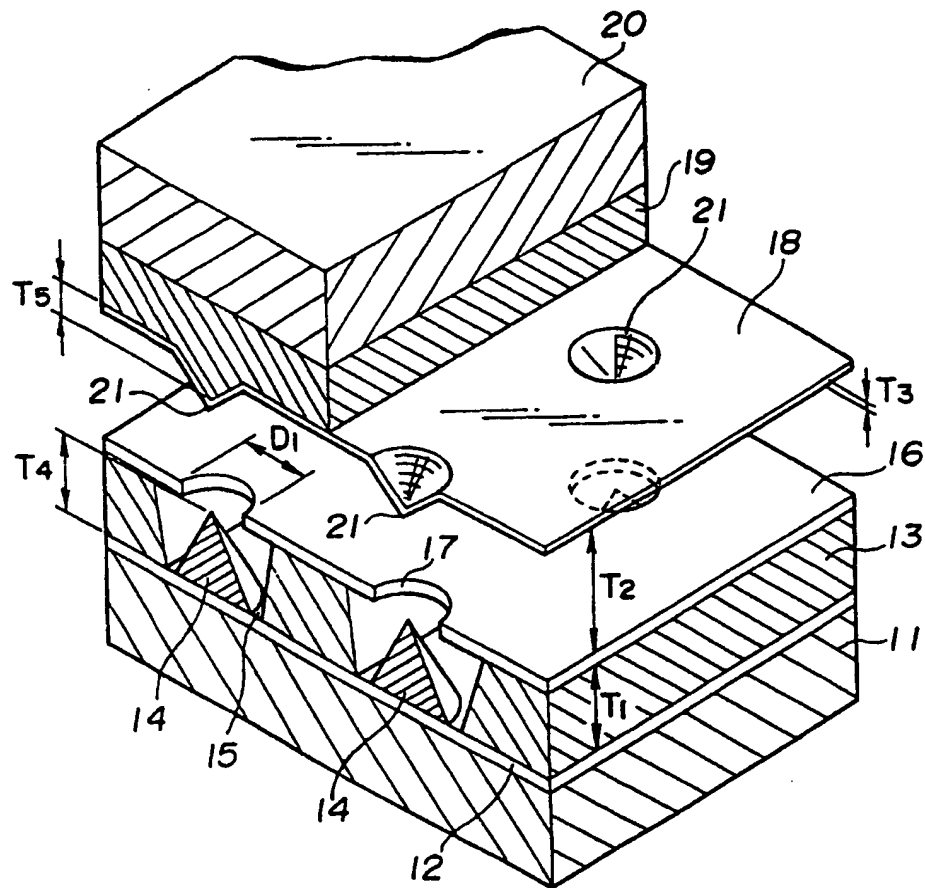
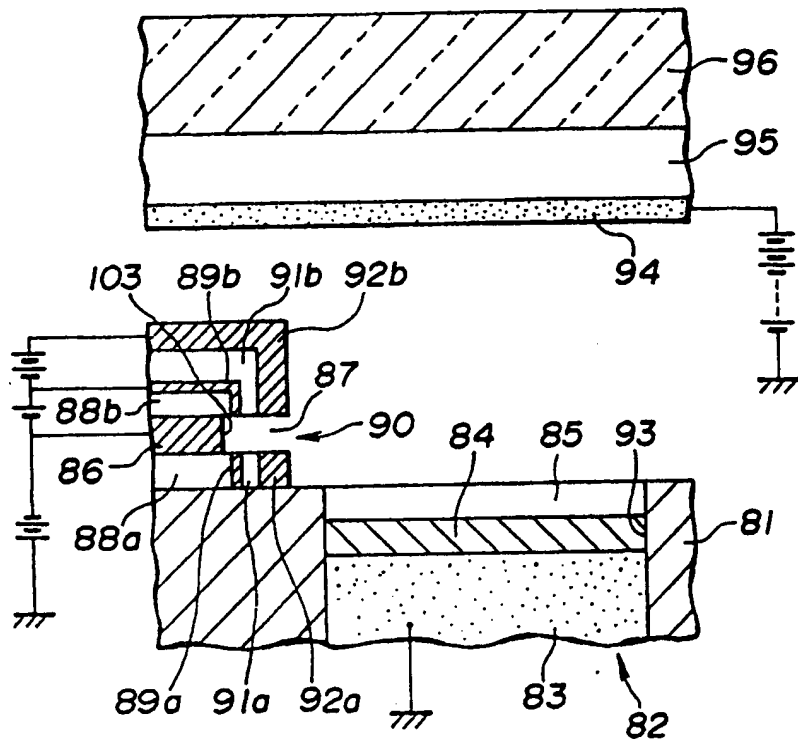
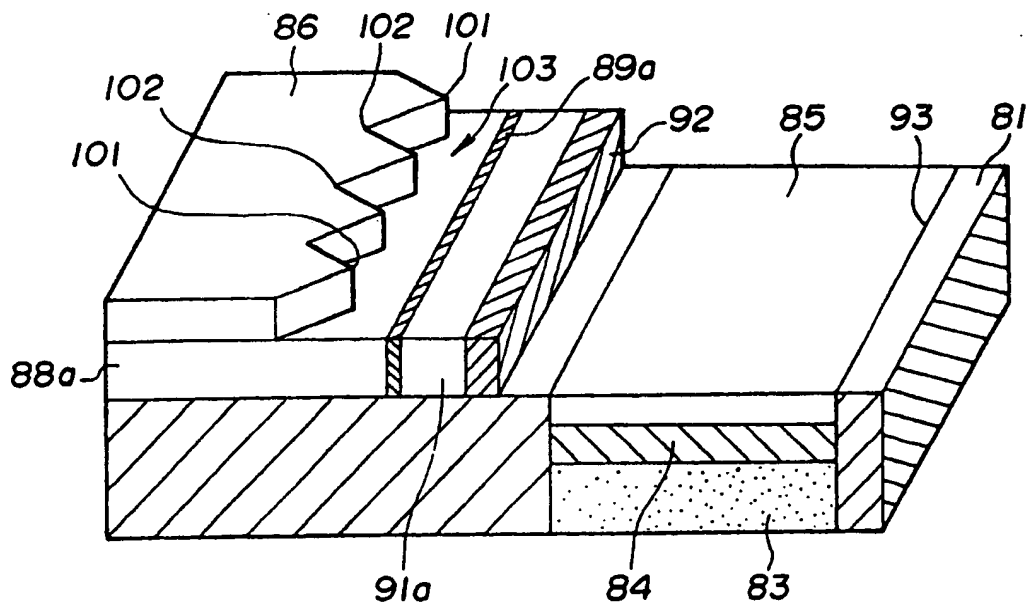
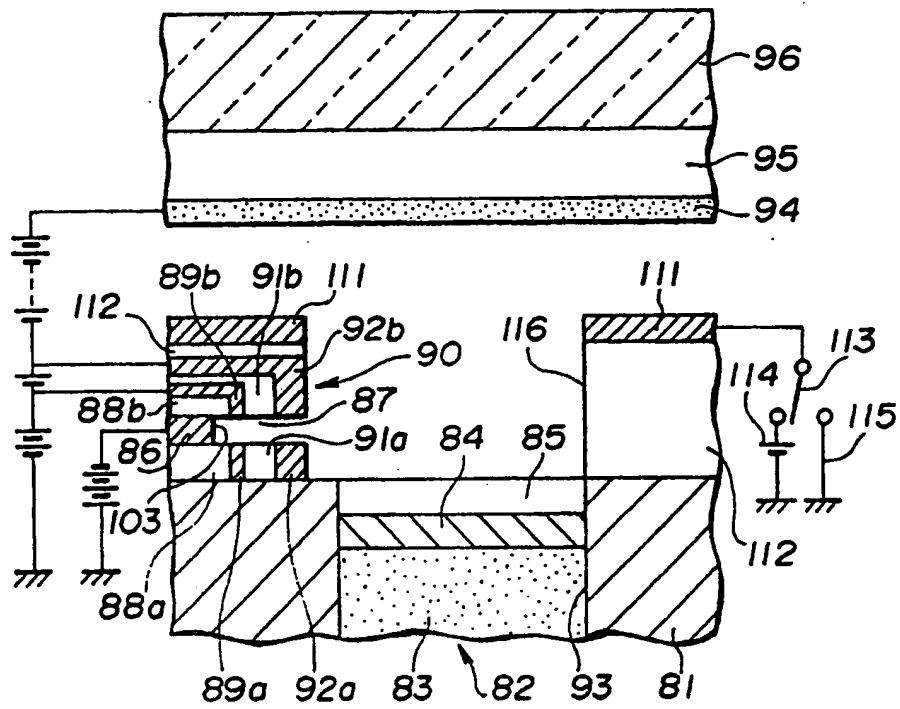
**FIG. 3****FIG. 4**

FIG. 6

**FIG. 7**

**FIG. 8**

**FIG. 9**

FLAT IMAGE-DISPLAY APPARATUS

This invention relates to flat image-display apparatus.

Flat image-display apparatus which could be used in place of a cathode ray tube in a television receiver has been studied. Such apparatus includes liquid crystal displays, electroluminescence displays and plasma display panels. Field emission type displays have also attracted attention in view of the brightness of the screen.

A field emission type display apparatus will be briefly described. Conical cathodes of molybdenum having a diameter not larger than $1.0\text{ }\mu\text{m}$ are formed as electron emission sources on a substrate, using a semiconductor manufacturing process. A flat gate electrode having a respective aperture for each cathode is formed near to the pointed ends of the cathodes, and a high voltage is selectively applied across the gate electrode and the cathodes. An electrostatic field is thus produced to extract electrons from the cathodes. A given picture is displayed on a screen by irradiating a light emitting layer (luminescence layer) disposed on the reverse side of an anode with the electrons. Such a field emission type display apparatus is described in, for example, US patent specification US-A-3 665 241 and in Japanese Unexamined Patent Publication 1/294336.

Figure 1 of the accompanying drawings is a sectional view showing an example of previously proposed field emission type display apparatus. A plurality of pointed cathodes 2 are formed on a substrate 1. A gate electrode 4 is formed on an insulating film 3 formed on the substrate 1. Electrons are extracted from the cathodes 2 by a voltage applied across the gate electrode 4 and the cathodes 2. The gate electrode 4 has respective apertures 4a each above one cathode 2. Electron beams from the cathodes 2 pass through the apertures 4a and collide with a flat anode 5 facing the substrate 1, and to which a high voltage is applied. The electrons reach a light emitting layer 6 on the reverse side of the anode 5 so that the layer 6 emits lights.

The dimensions of the display apparatus are as follows. The diameter of each gate electrode 4 is about $1\text{ }\mu\text{m}$. The radius of curvature of the pointed ends of the cathodes 2 is $50\text{ }\mu\text{m}$. Molybdenum or tungsten is used as the material of these components. The spacing between the cathodes 2 and the anode 5 is $200\text{ }\mu\text{m}$. A voltage of 300

voltage is applied thereacross. The drive voltage of the gate electrode 4 is 40 volts.

In such a field emission type display apparatus, the beams of electrons emitted from the pointed cathodes 2 tend to scatter, so
5 reducing the intensity of the light emitted from the light emitting layer 6.

The causes of this scattering will be described with reference to Figure 2 of the accompanying drawings, which shows a portion of Figure 1 on an enlarged scale. Figure 2 shows the distribution of the
10 potential between the substrate 1 and the anode 5. When a desired voltage is applied to the gate electrode 4, the equipotential surfaces E are curved towards the anode 5. This is referred as an electrostatic field lens. The electrons e^- are subjected to forces in a direction normal to the equipotential surfaces E, and are therefore scattered, so
15 reducing the intensity of the light emitted from the layer 6.

According to the present invention there is also provided a flat display apparatus, comprising:

- a substrate;
- a plurality of electron sources disposed on said substrate;
- 20 an electrode facing said electron sources via a vacuum space; and
- a light emitting means on the side of said electrode which is opposite to said substrate;
- said electrode source comprising a plurality of electron sources, the electrons being successively amplified by each electron source and
25 being incident upon the light emitting member.

The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Figure 1 is a schematic sectional view showing an example of a
30 previously proposed field emission type display apparatus;

Figure 2 is a sectional enlarged view of part of Figure 1;

Figure 3 is a sectional view showing the electrostatic field in a first embodiment of field emission type display apparatus of the present invention;

35 Figure 4 is an enlarged partly sectional and perspective view of the first embodiment of Figure 3;

Figure 5 is a schematic view showing the relation between

electrodes of the first embodiment of Figure 3;

Figure 6 is a schematic sectional view showing a second embodiment of field emission type display apparatus of the present invention;

5 Figure 7 is a schematic sectional view showing a third embodiment of field emission type display apparatus of the present invention;

Figure 8 is a sectional and perspective view showing the shape of a cathode of the third embodiment of Figure 7; and

10 Figure 9 is a schematic sectional view showing a fourth embodiment of field emission type display apparatus of the present invention.

Referring to Figure 5, the first embodiment of flat display apparatus comprises a cathode voltage supply unit 31 and a gate electrode 32 which are partitioned for each pixel and form an XY matrix
15 which is to be scanned. The cathode voltage supply unit 31 is formed with a plurality of cathodes 31a each of which emits electron beams. The gate electrode 32 has apertures 32a in positions corresponding to the positions of the cathodes 31a. The gate electrode 32 is disposed in a close relationship with the cathodes 32a. The electron beams pass
20 through the apertures 32a of the gate electrode 32. A flat planar anode electrode 33 is disposed on the side of the gate electrode 32 which is opposite to the cathode voltage supply unit 31. In this embodiment, the anode electrode 33 is formed with projections 33a corresponding to the cathodes 31a. An electrostatic field is converged
25 by the projections 33a to prevent the electric beams from scattering.

A voltage which is about several volts is applied across the cathodes 31a and the gate electrode 32. A voltage which is about several hundred volts is applied across the cathodes 31a and the anode electrode 33. Accordingly, the electron beams are emitted due to
30 voltage between the cathodes 31a and the gate electrode 32, and the emitted electron beams are directed towards the anode electrode 33 by the potential of the anode electrode 33. Since the anode electrode 33 is formed with the projections 33a as mentioned above, the electron beams are converged towards the projections 33a, so that the light
35 emitting layer located on the opposite side of the projections 33a emits light at a high efficiency.

The structure of the first embodiment will be further described

with reference to Figure 4. The embodiment comprises a substrate 11 and a cathode voltage supply layer 12 made of an electrically conductive material. A silicon oxide film 13 which is insulating is formed on the cathode voltage supply layer 12. The thickness T_1 of the silicon oxide film 13 is about 1 μm . The silicon oxide film 13 is formed with a plurality of recesses 15, so that the cathode voltage supply layer 12 is exposed on the bottom of the silicon oxide film 13. A small cathode 14 having a conical pointed shape is formed in each of the recesses 15. Each cathode 14 is formed of a metal such as tungsten or molybdenum. The pointed shape of the cathodes 14 is formed by using an oblique incident evaporation process or lift-off process. The cathodes 14 are preferably arranged on the cathode voltage supply layer 12 in a two-dimensional matrix manner. The pointed cathodes 14 are equilaterally triangular in section perpendicular to the main face of the substrate 11. The height T_4 from the bottom to the apex of the cathodes 14 is about 0.5 μm .

A thin gate electrode layer 16 is formed on the silicon oxide film 13. The gate electrode layer 16 is formed with a plurality of through-holes 17 in a two-dimensional matrix manner in positions corresponding to the positions of the cathodes 14. The diameter D_1 of the through-holes 17 is about 1 μm . Since the diameter D_1 of the through holes 17 formed in the gate electrode layer 16 is smaller than the diameter of the recesses 15 of the silicon oxide film 13, the gate electrode layer 16 extends in an inner radial direction over the recesses 15.

The anode which faces the cathodes 14, via a vacuum space, comprises a planar anode 18, a light emitting layer 19 made of a light emitting material formed on the side of the anode 18 which is opposite to the substrate side, and a front panel glass 20 provided on the side of the light emitting layer 19 opposite to the anode 18. The length T_2 of the vacuum space between the gate electrode layer 16 and the anode 18 is about 1 mm. The cathodes 14 and the anode 18 face each other so that the vacuum space is disposed therebetween, and electron beams from the cathodes 14 reach the anode 18. The vacuum pressure in the vacuum space is, for example, about 1.33×10^{-7} Pa (10^{-9} Torr).

The anode 18 is made of a planar aluminium thin film. In this

embodiment, projections 21 are arranged in a two-dimensional matrix in positions corresponding to the pointed conical cathodes 14. Each projection 21 is conical in shape and has an apex facing the apex of a respective cathode 14. The anode 18 has a substantially constant film thickness T_3 which is about 10 nm. The length T_3 of the projections 21 is, for example, about 1 μm . The diameter of the projections 21 is not limited to being smaller than that of the cathodes 14, and may be larger than that of the cathode 14. Also, the shape of the projections 21 is not limited to conical as shown in the drawing, and may be pyramidal, semi-spherical or a small square-pillar. Although the projections 21 correspond to the cathodes 14 one to one in the present embodiment, the present invention is not limited to this. One projection may correspond to a plurality of cathodes, and the projections 21 may be formed of a different material.

The light emitting layer 19 having a required thickness is formed on the anode 18. The light emitting layer 19 is irradiated with the electron beams which are emitted and transmitted through the anode 18, so that the light emitting layer 19 emits light. The front panel glass 20 made of a transparent material is formed on the light emitting layer 19. An image displayed by the apparatus is visible through the front panel glass 20 due to the emission of light from the light emitting layer 19.

Suppression of the scattering of the electron beams in the anode 18 having projections 21 will be described with reference to Figure 3, which corresponds to Figure 2. The anode 18 is electrically conductive, because it is made of an aluminium thin film, and therefore is at an equipotential which is about several hundred volts higher than the potential of the cathode 14. The equipotential curve E is changed depending on the shape of the projections 21 because the projections 21 extend beyond the surface of the anode 18 towards the cathode 14, and the potential gradient becomes high on the shortest line between the apices of the cathodes 14 and the projections 21. As a result of this, even electrons e^- which would otherwise be scattered are converged towards the projections 21 of the anode 18, so that the intensity of the impinging electrons is increased by the electrostatic field effect. This increase in the intensity of the electron beams increases the

intensity of light emitted from the light emitting layer 19, so that the brightness of the displayed image is increased to provide a sharp picture.

The first embodiment has been described with reference to the anode structure thereof. The effects of the present invention can be accomplished by increasing the intensity of the electron beams from the cathode to increase the intensity of the emitted light. This will now be described with reference to the second embodiment which is in the form of a flat display apparatus comprising a plurality of electron sources capable of emitting a plurality of electron beams and of irradiating a light emitting layer with them.

Referring to Figure 6, primary to quaternary electron sources 42 to 45 are formed on a substrate 41 in a multilayered manner. The electron sources 42 to 45 are separated into odd numbered electron sources 42 and 44 and even numbered electron sources 43 and 45 by a vacuum space 46, and face each other so that the vacuum space 46 is disposed therebetween. The primary to quaternary electron sources 42 to 45 are disposed so that the degree thereof increases from the substrate 41 towards an anode 47 made of aluminium.

The primary electron source 42 has a cathode 53 made of a metal such as molybdenum or tungsten sandwiched between interlayer insulating films 51 and 52 made of silicon oxide film. The cathode 53 is electrically earthed. The cathode 53 is preferably of saw-tooth shaped at the tip 53a thereof, so that the electrostatic field is concentrated. The cathode 53 is opened at the tip 53a thereof, so that electrons are emitted through an opening 54. Attracting electrodes 55a and 55b are located in the vicinity of the interface between the opening 54 and the vacuum space 46. Electrons are attracted from the cathode 53 by applying a suitable voltage across the electrodes 55a and 55b, so the primary electrons I are directed into the vacuum space 46.

The secondary electron source 43 faces the primary electron source 42 via the vacuum space 46 and is located between the substrate 41 and the anode 47 and is slightly closer to the anode 47 than is the primary electron source 42. The secondary electron source 43 comprises an electron source layer 57 made of caesium oxide or magnesium oxide and interlayer insulating films 56 and 58 which sandwich the electron source layer 57. A suitable positive voltage is applied to the

electron source layer 57. The electron source layer 57 is irradiated with the primary electrons I_1 emitted from the primary electron source 42 on the side of the layer 57 open to the vacuum space 46. As a result of this, amplified secondary electrons I_2 are emitted from the
 5 electron source layer 57.

The tertiary electron source 44 faces the secondary electron source 43 via the vacuum space 46 and is formed above the primary electron source 42 on the substrate 41, that is in a position closer to the anode 47 than is the secondary electron source 43. The tertiary
 10 electron source 44 comprises an electron source layer 60 therebetween. A voltage which is higher than a voltage applied to the electron source layer 29 of the secondary electron source 43 is applied to the electron source layer 60 of the tertiary electron source 44. The electron source layer 60 is irradiated with the secondary electrons I_2 from the
 15 secondary electron source 43 on the side of the layer facing the vacuum space 46. Accordingly, the tertiary electrons I_3 which are amplified from the secondary electrons I_2 are emitted into the vacuum space 46 from the electron source layer 60 of the tertiary electron source 44.

The quaternary electron source 45 is disposed in the side of the
 20 secondary electron source 43 of the vacuum space 46 and faces the tertiary electron source 44 via the vacuum space 46. The quaternary electron source 45 is formed with an electron source layer 62 made up caesium oxide or magnesium oxide. The electron source layer 62 of the quaternary electron source 45 is closer to the anode 47 than is the
 25 tertiary electron source 44. An interlayer insulating film 62 is formed on the side of the electron source layer 62 facing the anode 47 so that the electron source layer 62 is sandwiched between the interlayer insulative films 58 and 63. A voltage which is higher than a voltage applied to the electron source layer 60 of the tertiary
 30 electron source 44 is applied to the electron source layer 62 of the quaternary electron source 45. The electron source layer 62 is irradiated with the tertiary electrons I_3 from the tertiary electron source 44 on the side of the layer facing the vacuum space 46 similar to the tertiary and secondary electron source 43 quaternary electrons
 35 I_4 which are amplified from the tertiary electrons I_3 are emitted into the vacuum space 46 from the electron source layer 62 of the tertiary

electron source 45.

A gate electrode 64 is disposed on the sides of the interlayer insulating films 61 and 63 facing the anode 47, for controlling the irradiation of the anode 47 with the quaternary electrons I_4 by the electrostatic field established by the electrode 64. When a high voltage is applied to the gate electrode 64, the anode 47 is irradiated with the quaternary electrons I_4 . When a low voltage is applied to the electrode 64, and anode 47 is not irradiated with the quaternary electrons I_4 . The gate electrode 64 is formed with an opening 67 through which the vacuum space 46 which is disposed between the electron sources 42 to 44 extends to the anode 47. If electron sources each including a plurality of electron sources 42 to 44 are disposed in a two-dimensional matrix manner on the substrate 41, the openings 67 are correspondingly disposed in a two-dimensional matrix manner.

The anode 47 is disposed from the gate electrode 64 by a distance so that a vacuum space 68 is disposed therebetween. The anode 47 comprises an aluminium thin film having a face which is parallel to the main face of the substrate 41. A high voltage is applied to the anode 47. The anode 47 is about 10 nm in thickness. The electrons reach the anode 47 from the electron sources depending upon the electrostatic field established by the thin anode 47 and penetrate to the light emitting layer 65 formed on the opposite side of the anode 47. A number of electrons which has been substantially amplified by the plurality of electron sources 42 to 45 collide with the light emitting layer 65 formed on the side of the anode which is opposite to the substrate 41, so that the layer 65 intensively emits lights. A front panel glass 66 is formed on the side of the light emitting layer 65 opposite to the anode 47. A sharp picture imaged by the light emitted from the light emitting layer 65 is displayed through the front panel glass 66.

In this second embodiment, a voltage which is higher by 50 to 100 volts than that applied to the primary electron source 42 is applied to the secondary electron source 43, a voltage which is higher by 50 to 100 volts than that applied to the secondary electron source 43 is applied to the tertiary electron source 44, and a voltage which is higher by 50 to 100 volts than that applied to the tertiary electron

source 44 is applied to the quaternary electron source 45. Electrons are successively amplified by each of the electron sources to which step-wise higher voltages are applied at each strike thereon, and we successively fed towards the anode 47 through the vacuum space 46.

5 The energy of the electrons at this time is about 50 to 100 eV. The electrons emitted from the quaternary electron source 45 strike the anode depending upon the voltage applied to the gate electrode 64. Since the number of electrons is increased more than ten times at each of the electron sources, the quaternary electrons I_4 emitted from the
10 quaternary electron source 45 establish electron beams having a sufficient intensity. Accordingly, the light emitting layer 45 emits light having a high intensity, so that a sharp picture can be displayed at a high brightness.

 In this second embodiment, a plurality of electron sources are
15 arranged so that the electron sources face each other, and higher voltage are applied to the electron sources nearer the anode 47. However, the present invention is not limited to this arrangement. For example, a plurality of electron sources may be arranged on a plane so that electrons travel along arched paths between sources, and are
20 amplified in each of the electron sources and finally impinge on the anode. Although the number of the electron sources described is four, it may be three, five, six or some other number.

 The third embodiment of flat display apparatus uses the Malter effect for generating secondary electrons. Figure 7 shows part of the
25 embodiment. A secondary electron source 82 is formed on a part of a substrate 81 made of an insulating material.

 The secondary electron source 82 comprises a laminate formed in a recess 93 which is formed in the substrate 81. The laminate includes an aluminium film 83, a thin aluminium oxide film 84 laminated on the
30 aluminium film 83 and a caesium oxide film 85 laminated on the aluminium oxide film 84. The lowermost aluminium film 83 is at the earth potential. The aluminium oxide 84 formed between the aluminium film 83 and the caesium oxide film 85 is a thin film having a thickness of 50 to 100 nm. A number of electron beams are emitted from the
35 secondary electron source by a mechanism which will be described below.

 A primary electron source 90 is formed on the substrate 11 in the vicinity of the laminate including the three metal and metal oxide

films. The primary electron source 90 includes a cathode 86 having a saw-tooth shaped electrostatic field generating source, which serves as an electron emitting source. Figure 8 is a perspective view showing the shape of the cathode 86. The cathode 86 is formed into a flat member on a lower insulating film 88a, and is made of a metal such as molybdenum or tungsten. The electrostatic field generating side of the cathode 86 is saw-tooth in shape with peaks 101 and troughs 102 which are alternately disposed. The electrostatic field is concentrated at the peaks 101 to extract the primary electrons. The cathode 86 is sandwiched between the lower and copper insulating films 88a and 88b, and an opening 87 is formed on the electrostatic field generating side 103.

Upper and lower extracting electrodes 89b and 89a, and upper and lower accelerating grids 92b and 92a face each other in the opening 87. The upper extracting electrode 89b is disposed at one end of the upper insulating film 88b facing the secondary electron source, under which the cathode 86 is disposed. The lower extracting electrode 89a is disposed at one end of the lower insulating film 88a facing the secondary electron source, on which the cathode 86 is disposed. The upper and lower extracting electrode 89b and 89a are disposed in the vicinity of the electrostatic field generating side 103 of the cathode 86. The primary electrons are extracted from the cathode 86 by applying a suitable voltage to the upper and lower extracting electrodes 89b and 89a. The lower accelerating grid 92a is disposed on the main face of the substrate 81, so that the lower interlayer insulating film 91a is sandwiched between the lower extracting electrode 89a and the lower accelerating grid 92a. The upper accelerating grid 92b is disposed so that the upper interlayer insulating film 91b is sandwiched between the upper extracting electrode 89b and the upper accelerating grid 92b. The upper and lower accelerating grids 92b and 92a have a film thickness which is larger than those of the extracting electrodes 89b and 89a. A voltage which is higher than that applied to the extracting electrodes 89b and 89a is applied to the upper and lower accelerating grids 92b and 92a for accelerating the primary electrons in the opening 87. The energy which of the primary electrons is about 50 to 100 eV.

An anode 94 is disposed so that it faces the substrate 81, on

which the primary and secondary electron sources 90 and 82 are adjacent to each other. A vacuum space is disposed between the substrate 81 and the anode 94. The main face of the substrate 81 is disposed substantially parallel with the planar anode 94. A high voltage is applied to the anode 94 so that electrons generated by the secondary electron source 82 reach the anode 94. A light emitting layer 95 is provided on the side of the anode 94 which is opposite to the vacuum space. Electrons strike the light emitting layer 95 for emitting light. The light emitting layer 95 is sandwiched between the anode 94 and the front panel glass 96, so that a picture is displayed through the front panel glass 96.

In this third embodiment, primary electrons are extracted from the cathode 86 to the opening 87 by applying a voltage across the cathode 86 and the extracting electrodes 89a and 89b. The primary electrons are accelerated by the upper and lower accelerating grids 92b and 92a. The accelerated primary electrons are obliquely incident upon the surface of the caesium oxide film 85 causing it to emit secondary electrons. As a result of this emission of the secondary electrons, the caesium oxide film 85 is positively charged. This establishes an electrostatic field on the aluminium oxide film 84 which functions as a dielectric material. Since the aluminium oxide film 84 is a very thin film, a strong electrostatic field is established in the vicinity of the aluminium oxide film 84. Electrons are extracted from the aluminium film 83 by this strong electrostatic field (by the Malter effect) and are accelerated in accordance with the electrostatic field between the aluminium oxide film 84 and the anode 94. Many electrons which reach the anode 95 will reach the light emitting layer 95, so as to emit light therefrom. The number of these electrons is so high that the intensity of emitted light is high.

This third embodiment uses the Malter effect to cause many electrons to collide with the light emitting layer 95. Accordingly, the intensity of the emitted light for displaying the image can be substantially enhanced. Although the secondary electron source is a laminate film including the caesium oxide film 85, the aluminium oxide film 84 and the aluminium film 83, the secondary electron source is not limited to this form. It may, for example, be a laminate film including a magnesium oxide, a nickel oxide film and a nickel film.

The fourth embodiment which is a flat display apparatus with a gate electrode, will now be described with reference to Figure 9.

The fourth embodiment is substantially identical to the third embodiment, except that the fourth embodiment is formed with a gate electrode 111 enabling positive control of the number of electrons.

The gate electrode 111 is formed on an interlayer insulating film 112 which is formed on a substrate 81 and an upper accelerating grid 92a. The interlayer insulating film 112 and the gate electrode 111 are opened above a secondary electron source 82 for controlling the electrons passing through the opening 116 from the secondary source 82. The potential of the gate electrode 111 is controlled by a switch 113. The switch 113 switches the potential of the gate electrode 111 to that of an earth terminal of that of a terminal 114 of a suitable voltage. When the potential of the gate electrode 111 becomes earth potential, the electrons from the secondary electron source 82 are interrupted. When the potential of the gate electrode 111 becomes a suitable positive voltage, the electrons from the secondary electron source 82 pass through the gate electrode to collide with a light emitting layer 95.

Addition of such a gate electrode 111 enables the number of electrons emitted from the secondary electron source 82 due to the Malter effect to be controlled. Similarly to the third embodiment, the intensity of emitted light for image display can be substantially enhanced. Accordingly, a sharp and bright picture can be provided.

Also in the fourth embodiment, the laminate film in which the Malter effect occurs, may be a laminate including a magnesium oxide film, and is not limited to a laminate film including a caesium oxide film, an aluminium oxide film and an aluminium film.

Attention is drawn to two other patent applications describing and claiming similar subject matter. These are our application 9204704.2 (432254486) on which the present application is divided, and our application 9217605.6 () (our reference N606-2 filed on the same day as the present application) and also divided on application 9204704.2.

CLAIMS

1. A flat display apparatus, comprising:
a substrate;
5 a plurality of electron sources disposed on said substrate;
an electrode facing said electron sources via a vacuum space; and
a light emitting means on the side of said electrode which is opposite
to said substrate;
said electrode source comprising a plurality of electron sources, the
10 electrons being successively amplified by each electron source and
being incident upon the light emitting member.
2. A flat display apparatus subsequently as hereinbefore described
with reference to Figure 6 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under
Section 17 (The Search Report)

Application number

GB 9217604.9

Relevant Technical fields

(i) UK Cl (Edition K) H1D - DABXA, DAB6, DAF1, DAC1,
DAC4, DAF10, DPB, DPD

(ii) Int Cl (Edition 5) H01J

Search Examiner

R H LITTLEMORE

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

20 NOVEMBER 1992

Documents considered relevant following a search in respect of claims 1, 2

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1518238 (RCA) - eg see Figure 3	1
X	GB 1515428 (RCA) - eg see Figure 2 and description	1
X	GB 1174038 (NORTHROP) - eg see Figure 5	1
X,E	EP 0476975 A1 (YEDA RESEARCH) - see Figure 5 and description	1
X,P	EP 0461657 A2 (SONY) - see Figures 6 and 9 and column 9 lines 28-56 and column 10 lines 12-35	1
X	EP 0318116 A1 (N V PHILIPS) - eg see Figure 2 and description	1
X	EP 0107217 A1 (PHILIPS) - see Figure 1	1
X	US 4115719 (CATANESE) - eg see Figures 3-6	1
	The above are examples only of a number of similar disclosures	

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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